U.S. Department of
Federal Aviation Administration

Aeromedical Research Resume
Research Project Description Subtask for FY00

1. Title: General Aviation Human Factors Research Program: Performance Assessment Tools and Training Systems	***2. Sponsoring Organization/Focal Point (FP)*** AIR-3; N. Lane AAI-1; B. Donner AAM-1; J. Jordan, M.D. ACE-110; M. Dahl AFS-400; R. Wright AFS-800; M. Henry AAR-100; R. Simmons	***3. Originator Name, Organization, Phone :*** **AAM-510 (405) 954-6828** Thomas E. Nesthus, Ph. D. Dennis B. Beringer, Ph.D. Kevin W. Williams, Ph.D. Kurt Joseph, M.S.
		4. Origination Date: July 1999
5. Parent RPI Number: Flight Deck Human Factors	***6. Subtask Number:*** AM-A-00-HRR-520	***7. Completion Date:*** September 2002
8. Parent MNS: 187	***9. RPI Manager Name, Organization, Phone:*** David J. Schroeder, Ph.D. AAM-500, FAA Civil Aeromedical Institute (405) 954-6825	

10. Research Objective(s):

This ARR concerns an approach to providing a scientific basis for the FAA and the GA industry to ascertain and develop initiatives that will result in the improvement in general aviation safety. Specifically, the research tasks of this ARR are designed to: (1) define and describe the capabilities and limitations of the average General Aviation Pilot, (2) evaluate selected intervention strategies, as identified by the Weather and CFIT Joint Safety Implementation Teams (JSIT), as well as strategies for reducing stall-related incidents/accidents, (3) examine the long-term effectiveness of PCATDs and other aviation training devices, (4) analyze human-factors-related causes of aviation accidents and incidents, (5) assess the impact of aviation stressors, including fatigue, on pilot performance under specified flight conditions and levels of pilot training/experience, (6) the development of specialized assessment procedures and questionnaire probes for providing baseline data on safety-related issues, training, and pilot performance, and (7) provide support for the development of advisory circulars and other informational materials for educational purposes.

11. Technical Summary:

This ARR includes a multi-task approach to meeting the research objectives noted above. Many of these tasks will involve laboratory research and simulation to investigate specific factors and conditions, which are felt to impact GA pilot performance. Other tasks will require database analyses and survey-style inquiries. The primary research tools in conducting the simulator-based research will be CAMI's two GA flight simulators: the Advanced General Aviation Research Simulator (AGARS) and the Basic General Aviation Research Simulator (BGARS). Research protocols, scenarios, and flight regimes will be configured to emulate the flight environment critical to the human factors research question under study. Recommendations are to be provided based on empirical pilot performance data obtained from high-fidelity real-time simulation. Wherever appropriate, pilot-subject response data will be presented in the form of probability functions, performance curves, and other graphic and probabilistic data presentation, which will support Agency actions. Human engineering design and/or instructional system design recommendations will be offered to improve the pilot-aircraft system interface, mitigate pilot error, expedite training, and enhance flight safety.

12. Resources Requirements:	FY-00	FY-01	FY-02
FAA Staff Years	5.0	5.0	5.0

13. Description of Work:

(1) Brief Background

This ARR has components from earlier ARRs in which the effects of environmental stressors and fatigue were examined for their impact on pilot performance. Contributions were and continue to be made to developing certification criteria for pilots and for aircraft as well as operating rules for aircraft systems, and determining the training effectiveness of PCATDs for purposes of approval of training devices and curricula. Continuing support (system development and testing & evaluation) for the AGATE program (training) and the follow-on SATS program is provided within the tasks in this ARR.

(2) Statement of Work

This is a multiple-task ARR and includes tasks with several component phases or stages where there is a transition of attention to follow-on issues and problems as a function of the degree of success of earlier efforts. Components of tasks that were completed under a previous ARR are noted. Several new tasks have been identified in coordination with AIR, including assessing causes of human error in accidents and defining standardized human/system performance criteria for pilot and aircraft certification.

General Hypothesis: that analyses of pilot abilities and accident causal factors can be used to identify areas for key interventions using various technologies and procedures, these interventions then producing statistically significant gains in one or more measures of pilot performance and contributing significantly to accident/incident reduction.

Task 1 – General Aviation Pilot Demographics.

Studies of GA pilots' responses to autopilot failures and malfunctions included in an earlier ARR indicated that criteria used for the certification of some aircraft systems did not necessarily match the performance capabilities of average GA pilots. These criteria were somewhat "optimistic" regarding the responses that one could expect of this pilot population, and thus some of the pilots were necessarily put at risk when called upon to respond to system failures or malfunctions, despite the fact that these systems could be said to be certification compliant. This task will examine, in the form of meta analyses and strategic sampling where necessary, the performance capabilities and limitations of the *average* General Aviation pilot. These data will then be used to produce recommendations for the design and certification of both aircraft systems and of pilots such that these recommendations accurately take into account not only the best possible expected performance but also the worst possible expected performance given the licensing and currency criteria used today.

Task 2 Evaluation of selected intervention strategies for Weather/CFIT-related and stall incidents/accidents.

Recommendations provided by the Joint Safety Analysis Teams for GA Weather and CFIT accidents are currently under review by Joint Safety Implementation Teams. A selection of the intervention strategies considered by the JSITs as top candidates for implementation will define the empirical work of this task. For example, a strategy for enhancing the quality and dissemination of GA weather information for pre-flight planning could be evaluated in two parts. Part (a), Create a protocol for a GA weather decision-making simulation, to systematically test and evaluate GA pilots' use of pre-flight weather information contained in several, currently available formats (e.g., DUATS, FSS Standard Briefing, and Graphical Weather Products). Weather information will be provided such that pilots receive equivalent information irrespective of the format used. The protocol also will evaluate formats and procedures used to provide in-flight weather briefings to GA pilots.

Measures will be developed to assess pilot comprehension of pre-flight and in-flight briefings, tactical and strategic weather decision-making, and flight performance. Strategic decision making will be evaluated by analyzing pilot responses to questions derived from pre-flight briefing material, whereas tactical decision making will be evaluated by analyzing pilot responses to material presented during in-flight weather briefings.

Part (b), Conduct a GA weather decision-making simulation, to collect empirical data using pilot comprehension, decision making, and performance measures. Analyze data to evaluate formats and procedures for obtaining pre- and in-flight weather information. Complete a technical report using analysis of empirical data and provide recommendations for improving formats and procedures used to obtain weather information. Recommendations for disseminating graphical weather information to the cockpit should be sensitive to weather products and services currently being developed for the FAA Flight Information Services (FIS) program.

Task 3 - Long-term training effectiveness of PCATDs and other Aviation Training Devices

The use of PC-based Aviation Training Devices (PCATDs) has been approved via Advisory Circular 61-126 as an acceptable means of providing some of the training required for an instrument rating. It has been demonstrated, however, that a major problem exists among pilots regarding the effective retention of flying skills in the time following initial certification. Research has indicated that spaced instructional interventions can be used to maintain flight skills and that those skills that deteriorate most rapidly are generally procedural in nature. Currently sponsored research with the University of Illinois Institute of Aviation is evaluating the possible use of affordable simulation to provide some of these instructional interventions. The research results will have the benefit of increasing the availability of instrument flight practice, decreasing the cost of the associated training, and reducing the hazard exposure of both the trainee and other individuals in the nearby environment. The research involves the comparison of four groups of pilots over time to determine the effectiveness of different training/recurrency interventions: a control group with no practice or instrument flying between pretest and posttest, a second control group that practices in the aircraft, an experimental group receiving practice on a PC-based device (one approved for use in instrument training), and an experimental group receiving practice time in a conventional aviation training device. Performance is being assessed for 12 flight tasks and will be correlated with flight training experience and currency variables. Results will be used to recommend appropriate use of the PCATD in the maintenance of instrument flying skills. In addition, as an adjunct to the current research, a study will be made of the effectiveness, reliability, and validity of the use of a GPS-based airborne recording system for the objective measurement of pilot performance during instrument maneuvers. This system will avoid the limitations of subjective evaluations of instructor pilots and will build on previously sponsored research. Research on PCATD effectiveness was initiated in FY98 and will continue through FY00. Efforts will be initiated to expand this research to assess the efficacy of selective aviation training devices.

Task 4 – Human Factors Analyses of Aviation Accidents.

Overall objectives of this tasking are to provide a better methodology for acquiring, recording, and analyzing the human factors aspects of aircraft accidents (including General Aviation). Accurate information concerning human factors provides aeromedical researchers and operational field management with critical trend information necessary for the development of accident prevention programs. Such a program, would reach the aviation community through pilot training materials, Advisory Circulars, and/or changes in the Federal Aviation Regulations based on accident data.

Application of the Human Factors Analysis and Classification System (HFACS) to Department of Defense (DoD) aircraft accidents, has afforded the ability to develop objective, data-driven intervention strategies. HFACS provides a model or framework for understanding the “big picture,” it highlights important human factors safety issues and their interrelationships, and helps target the need for specific intervention strategies.

The framework has also been used to develop innovative accident investigation methods that have enhanced both the quantity and quality of the human factors information gathered during accident investigations. Recent JSAT efforts in the analysis of general aviation CFIT and Wx-related accidents have underscored difficulties in

data analysis due, primarily to a lack of data.

Tasks associated with this project include application of the HFACS taxonomy to a sampling of civil aviation accidents (Parts 121, 135, 91 and rotorcraft) in an effort to verify the NASA Langley Reseach Center's Aviation Safety Analysis and Functionality Evaluation (ASAFE) tool, development of a field investigator's HFACS-checklist, and eventually, the development of an electronic field investigation tool. This task will be done in collaboration with the University of Illinois Institute of Aviation.

Task 5 – Fatigue in General Aviation and Regional Carrier flying*.*

Part (a): General Aviation. Fatigue in Single Pilot Business Flying (AGARS). The Piper Malibu configuration of the AGARS will be used to simulate a high-performance, single engine aircraft platform to measure levels of fatigue and loss of alertness induced by a pilot/business person's day. The protocol will involve approximately a 12-hour day in which the pilot departs home airport around 0700, flies a multi-hour mission to a meeting in another city, attends the meeting, and departs for a return-home flight at around 1700, arriving back at the home airport after the multi-hour return flight. Research objectives include (1) determining if significant fatigue effects and performance impairment are found as a result of the business flying protocol; (2) determining whether fatigue assessment methods developed earlier demonstrate a reliable sensitivity to the effects of fatigue in the simulation; and (3) determining whether real-time sensing of loss-of-alertness and fatigue effects based on the assessment methods is feasible and whether an alerting provision might effectively stimulate the pilot to take appropriate countermeasures. The results of this study will (1) indicate the degree of impairment in pilot performance as a result of long, business flying days, and (2) provide guidance in how to design and use real-time sensing devices for protecting the pilot against performance impairment due to fatigue effects.

Part (b): Regional carrier and unscheduled Part 135. In 1995, 1,546 Part 135 regional aircraft flew 3,033,773 hours at a cost of 11 accidents with a rate of .43 accidents per 100,000 flight hours as compared to Part 121, where the accident rate was .27 per 100,000 flight hours. FAR Part 119, which applies the regulatory requirements of Part 121 to regional aircraft now operating under Part 135, created a higher safety standard by requiring changes in flight crew qualifications, cabin safety equipment and materials, airplane performance requirements, aircraft dispatching, and maintenance. However, the regional airline operational environment still differs from the operational environment of "long-haul" carriers, and these important differences seemingly affect regional airline safety, as is evidenced in the difference in accident rates. For example, regional airlines fly into smaller airports, spend proportionately more time in IMC conditions, encounter terminal area traffic densities more frequently, and fly a higher number of take-offs and landings per day. Fatigue issues pertaining to high workload, long workdays, and irregular, unpredictable schedules, as frequently involved in operations of regional airlines, will be investigated using appropriate fatigue and performance assessment methods in a simulated cockpit operational environment.

Further, level of pilot experience in regional airlines is, on average, less than that for Part 121 Pilots. In 1994, the NTSB reported that these factors might combine in an interactive fashion to increase the risk of critical mistakes that could jeopardize the safety of flight. Human factors research is needed that discerns the exact nature and effects of these factors on pilot performance, and identifies high-payoff approaches for reducing risk and managing uncertainty in regional airline operational environments. In particular, pilot-in-the-loop simulations of regional airline operational contexts can provide pilot performance data that meet these objectives. Such simulations would (1) address the impact of automation on crew task performance; (2) reveal the effects of mission duration and evolution on crew fatigue levels; (3) identify pilot error and strategies to mitigate such error; (4) allow for more optimal integration of the dispatcher function; (5) test fatigue countermeasures; (6) provide pilot performance data that complement current agency efforts to certify aircraft for use in supercooled large droplet (SLD) icing environments; (7) clarify the implications of "free flight" on the regional airline operational environment and pilot performance; and so forth.

Findings from the part (a) study of GA pilot fatigue will be employed in the design and conduct of this study. The primary research tool will be AGARS configured as a twin turboprop commuter aircraft. Objectives include (1) determining the level and onset of fatigue effects as a function of commuter airline missions; (2) testing the value of fatigue assessment methods employed in earlier studies; and (3) assessing the usefulness and cockpit practicality of real-time loss-of-alertness sensing instrumentation and efficacy of recommended aircrew countermeasures.

Decision making regarding the initiation of this task and establishment of milestones is dependent upon the outcome of pending rulemaking and additional review of requirements.

Task 6 - Development and implementation of specialized assessment procedures and questionnaire probes for enhancing performance.

FAA personnel involved in aviation regulation and certification provide a critical link with flight operations in determining the overall level of safety maintained within the National Airspace System (NAS). Optimal performance is determined in part by the overall quality of the selection and training programs, the procedures and the work tools available, as well as other aspects of the overall corporate climate. With NAS modernization there will be a need to develop new procedures and technological approaches to accomplishing various job tasks. Information can also be gathered from general aviation pilots and others regarding their perceptions of various changes. This research task is designed to develop specialized assessment procedures and questionnaire probes that will provide baseline data for assessing employee and pilot views of safety-related issues, training, and performance. That information will, in turn, be used to assess the effectiveness of new technologies and procedures in optimizing performance and enhancing the overall corporate culture, including information gathered as part of the biennial FAA employee attitude survey (EAS). Work has been ongoing related to the EAS, the Alaskan survey on CFIT based upon HFACS, and in support of technology-based transitions in the Aircraft Registry.

14. Intended End Products/Deliverables:

Efforts on this ARR will result in products which will be delivered through such media as advisory circulars (AC's); DOT/FAA/CAMI informational pamphlets distributed to the GA community; educational materials provided to FAA safety counselors for distribution and presentation; guidelines for certification and rule making; equipment design specifications provided to GA equipment manufacturers (most notably AGATE industry partners); general human engineering guidelines for the design and integration of GA cockpit instrumentation; and so forth. Results of scientific studies will be documented in technical reports and memoranda, reported to sponsors at project review meetings, with a selected number being presented at professional meetings and submitted for publication in the scientific literature.

Task 2: Intervention lists for CFIT/Weather-related, and stall incidents	
2.1 Create a protocol for GA Weather decision-making simulation	FY99 Q4
2.2 Test protocols and verify sensitivity of measures	FY00 Q1
2.3 Conduct GA Weather decision-making simulation	FY00 Q1
2.4 Data analysis	FY00 Q2
2.5 Submission of final report	FY00 Q3
Task 3: Long-term training effectiveness of PCATDs and other Aviation Training Devices	
3.1 Completion of PCATD effectiveness data collection (University of Illinois)	FY00 Q2
3.2 Development of plan for evaluation of aviation training devices	FY00 Q3
Task 4: Human Factors Analyses of Aviation Accidents	
4.1 Scheduled 121 & 135 (FY90-present) coded and analyzed (University of Illinois)	FY99 Q4
4.2 Literature review on HF accident investigation (University of Illinois)	FY00 Q1
4.3 Report completed for 121 & 135 data (University of Illinois)	FY00 Q2
4.4 Begin analysis of GA accidents	FY00 Q2
4.5 Electronic field investigation tool completed	FY00 Q4
4.6 Begin constructing relational database of causal factors	FY00 Q4
Task 5: Fatigue in General Aviation and Regional Carrier Flying	
5.1a Design Study	FY99 Q4
5.2a Develop supporting displays & simulation software	FY00 Q1
5.3a Collect/analyze data	FY00 Q2
5.4a Report findings; make recommendations	FY00 Q3
5.1b Identify future study requirements	TBD
Task 6: Development of specialized assessment tools	
6.1 Alaskan survey developed based upon HFACS	FY99 Q1
6.2 Alaskan survey mailed out	Completed
6.3 Alaskan survey data analyzed	FY99 Q2
6.4 Alaskan survey final report	Completed
6.5 Other specialized assessment tools as required	FY99 Q3
	Completed
	FY99 Q4
	Ongoing

16. Procurement Strategy/Acquisition Approach/Technology Transfer:

Technology transfer to the general aviation equipment and training communities will be accomplished through such organizations as GAMA, SAMA, AOPA, through the AGATE, and through circulars and other media to the GA pilot community. It is anticipated that additional hardware/software support will be required to upgrade AGARS in support of this specific research. Procurements to upgrade the device to fully support other aero model configurations and performance monitoring subsystems will cost an estimated $1OOK.

17. Justification/History:

NTSB civil aviation accident data for 1998 indicate that of the total of 2040 accidents (1995: 2,188), 1,907 or 93% were associated with general aviation (1995: 94%). Of the total number of accidents, 361 were fatal (1995: 438) with general aviation accounting for 96% (1995: 93%). Total fatalities for 1998 were 663 (1995: 961) with 621 or 94% attributable to general aviation (1995: 76%). Note that general aviation includes all aviation operations with the exception of air carrier and the military. (Information was taken from the NTSB Annual Review of Aircraft Accident Data, 1998 Preliminary Data.) General aviation, due to its relatively high accident and fatality rates, offers a potentially high return on investment of R&D resources because of the larger potential payoff in increased aviation safety from interventions that serve to reduce those rates.

It has been estimated that over 80% of the accidents noted above within the general aviation community can be attributed to some form of pilot error. GA pilot "errors" may be precipitated by any number of causal factors including inappropriate decision-making, poor judgment, inappropriate attitudes toward flying, lack of the necessary skill level required for a particular set of flying conditions, or lack of knowledge of weather, procedures, rules, or regulations. Such "errors" could also be due to impairment induced by fatigue, drugs, alcohol, stress, hypoxia, preoccupation, or other stressors. In addition to those potential causal factors, GA accidents and incidents can also be attributed to confusing navigational charts, poorly conceived airspace restrictions, lack of standardization between aircraft, poorly designed cockpit interfaces including controls and displays, confusing avionics input and output entries, and new technology to which the GA pilot must adapt. This ARR is dedicated to developing and testing interventions that will serve to reduce the root causes of GA pilot "errors" and thereby achieve a reduction of GA accidents and incidents. Some of these interventions will arise from the application of emerging technology through AGATE. Supporting justification for this project area also can be found in Public Law 100-591, the Aviation Safety Research Act of 1988, and the Federal Air Surgeon's Annual Program Guidance Policy Statement, 1992-1993 which supports research on pilot impact of recent changes in the cockpit environment and assessment of pilot attributes required to perform safety in current and future advanced cockpits. The National Plan for Civil Aviation Human Factors also stresses the urgency of fully integrated human factors research. These activities are also in response to the report of the Gore Commission and its call for interventions to reduce the aircraft accident rate, and are in support of the Safe Flight 2000 initiative.

18. Issues:

Human subjects will be used and, as such, each will be informed of the tasks to be required. No drugs or alcohol are to be used in the research. A description of the research protocol and subject consent form will be submitted to the FAA Institutional Review Board for approval. Support will also be provided for the “ATS concept of operations for the National airspace System in 2005.”

19. Transition Strategy:

Transition of R&D findings from the ARR will be accomplished through existing FAA structures within the Flight Standards organization, Office of Accident Investigation, GA safety counselors, and Aircraft Certification. Recommendations will be provided regarding revisions to FAR's and issuance of advisory circulars. Other transitions will be accomplished through representation at GA industry expositions and technical meetings and through the NASA AGATE, SATS, and AWIN programs. Transition will also be facilitated by continued coordination with the General Aviation Coalition and participation with the four working groups currently operating within that organization.

20. Impact of Funding Deferral:

Deferred funding of this project would likely result in significant delays in understanding the contribution of the specified avionics devices and situations to aircraft accidents and incidents. This would translate into a continuance of general aviation accidents at an unabated rate (1,907 in 1998), many of which involve fatalities (361 in 1998), and the accompanying loss of life and property damage. One can not discount the indirect costs to society related to subsequent insurance claims, lost wages and productivity, and litigation as well as investigatory costs to the agency. Deferral would also significantly restrict or prohibit participation in the AGATE and SATS programs and compromise application of human factors standards and criteria to the developing avionics and control systems.

21. R&D Teaming Arrangements:

CAMI will collaborate with other federal laboratories and university research centers important to the accomplishment of the stated research objectives. In particular, coordination will be maintained with the NASA general aviation program currently being managed at NASA Langley. Continued coordination and participation will be maintained with the General Aviation Coalition composed of FAA-AFS, AOPA, GAMA, SAMA, EAA, and NBAA. The goals of this plan are shared by this ARR and include aviation safety, product innovation and competitiveness, air facilities capacity and access and affordability of innovations by the GA pilot community. Additional support for Tasks will be obtained through grants to the New Mexico State University, the University of Illinois Aviation Research Laboratory and other institutions. Teaming with CAMI's Aircraft Accident Research Team (AAM-600) will be pursued where appropriate.

22. Special Facility Requirements:

The General Aviation Flight Simulation Research Facility at CAMI including both AGARS and BGARS will be used in the performance of most experimental tasks.

***23. Approvals (Signature Authority)*:**	***Project Revalidation***	***Performing Organization***
_____ Nancy Lane Special Assistant to the Director Aircraft Certification Service (AIR-3)	_____ Date	_____ William E. Collins, Ph.D. Director, FAA Civil Aeromedical Institute, AAM-3
_____ Jon L. Jordan, M.D. Federal Air Surgeon, AAM-1	_____ Date	_____ Date